

star), then the observed velocities above recorded should be comparable with those computed from Belopolsky's data.

			$\frac{dz}{dt}$ km/sec.	Cam- bridge Obs.
C. 382	1896 Nov. 4 ^h 60	= 1896 Feb. 28 ^h 82 + (2 ^h 91 × 85) + 2 ^h 44	+ 39	- 42 ^h 3
C. 385	1896 Nov. 5 ^h 53	= 1896 Feb. 28 ^h 82 + (2 ^h 91 × 86) + 0 ^h 46	- 39	+ 30 ^h 8

The photographs show a change of velocity quite comparable with that discovered by Belopolsky, but exactly opposite in phase. The period 2^h 91 is not accurately enough known for the calculation of an ephemeris so far ahead as seven months. It would appear that an odd number of half periods has been lost or gained between April and November. Belopolsky's discussion of thirty-two photographs pointed to some possible variation in the period, and it is to be hoped that he has secured more evidence in the present year.

The photographs obtained at Cambridge, however, appear to support Belopolsky's most interesting discovery, that in the system of *Castor* two periods must now be recognised, one about 1000 years, the other probably less than three days.

On a New Binary Star with a Period of 5½ Years (β 883).
By T. J. J. See, A.M., Ph.D. (Berlin).

For several months I have been practically certain that the double star β 883 = Lalande 9091, $\alpha = 4^h 44^m 33^s.0$, $\delta = +10^\circ 52'$ (1875.0) is revolving in a period of about 5.5 years, and thus describing its orbit in less than one-half the time required for the most rapid system heretofore known; but it seemed desirable to withhold any announcement of such an extraordinary result until the observations should remove every reasonable doubt of the correctness of the conclusion. Indeed, this hypothesis first presented itself to my mind in the summer of 1895, when I was examining the orbits of all known binaries with a view to selecting those most accurately determined for incorporation into the work recently published (*Researches on the Evolution of the Stellar Systems*, vol. i.).

Professor Schiaparelli had very kindly communicated by private letter a number of his unpublished observations of this star, and on combining these with other measures in my possession it seemed clear that only a period of about 5.5 years would satisfy the observations. Professor Burnham, however, did not regard the evidence as conclusive, and I decided to wait till further measures were available. On entering upon the measurement of southern double stars I felt that notwithstanding the northern position of this object the great interest attach-

ing to it would justify occasional examination with the Lowell 24-inch refractor. Accordingly I observed it at Flagstaff in September, and have since continued the observations every month, except when the Observatory was in process of removal to Mexico. These observations since 1896 September furnish the key to the situation ; and as the Sun is now rapidly overtaking the star, and it cannot be followed much longer this year, the present is a favourable time to present to the Society the results at which we have arrived. In the sweeps for new double stars I am assisted by Mr. W. A. Cogshall, S.B., who generally examines all objects of difficulty, and at different times has secured a considerable number of measures. His work has been done with care and precision, and I have valued his judgment in all cases of doubt. In our observations of this star we are in entire accord.

Individual Observations of β 883.

<i>t</i>	θ_0	ρ_0	Observers.	Remarks.
1879 ⁰⁰	[197 ⁵] 17 ⁵	0 ³⁵	Burnham	
1887 ⁰⁹⁶	84 ³	0 ¹⁵	Schiaparelli	Very difficult.
'170	85 ⁰	0 ¹⁵	"	" "
'172	84 ⁷	0 ¹⁵	"	" "
1888 ⁰⁵⁵	119 ⁵	0 ¹⁸	"	
'066	129 ⁴	0 ¹⁸	"	
'142	...	...	"	Simple.
1889 ⁰¹⁷	137 ⁰	...	"	Doubtful.
'065	...	...	"	Simple.
'176	158 ⁸	0 ¹⁵	"	
'192	158 ³	0 ²⁰	"	
'195	144 ²	0 ²⁵	"	+ 180 ⁰ 0 ?
1890 ¹³⁰	200 ⁷	0 ¹⁵	"	Doubtful.
'132	206 ⁹	0 ¹⁵	"	"
'149	202 ⁸	0 ¹⁸	"	"
1891 ¹¹⁴	Single	Many nights	Burnham	
'146	...	...	Schiaparelli	Single.
'149	...	...	"	"
'785	125 ²	0 ¹²	Burnham	
1892 ⁰⁵⁷	116 ⁴	0 ⁰⁶	"	
'060	127 ⁸	0 ¹²	"	
1893 ⁰⁷²	...	...	Schiaparelli	Single.
1894 ¹⁴⁶	...	...	"	"
'165	...	...	"	"
'65	173 ⁵	0 ²⁰	Barnard	

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with a Period of $5\frac{1}{2}$ Years.

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<i>t</i>	θ_0 °	ρ_0 "	Observers.	Remarks.
1895·146	...	...	Schiaparelli	Uncertain.
·745	186·0	0·43	See	Good images.
·746	186·8	0·35 ±	„	Separated.
·745	188·9	...	Moulton	„
1896·692	9·9	0·17 ±	See	Distinctly elongated, but no trace of separation.
·693	12·0	0·14 ±	„	
·728	28·7	0·25 ±	„	Elongated, but not separated.
·843	22·8	0·18 ±	„	Elongation very distinct.
·844	23·8	0·17 ±	„	Notched under power of 1000.
1897·028	34·6	0·28 ±	„	Well separated, but very close.
·118	34·2	0·28	„	Distinctly separated. Good measures.
·162	35·5	0·25	„	Nicely separated.
·162	36·0	0·35	Cogshall	
·192	37·8	0·35	See	Distinctly separated, with black line between.
·193	37·1	0·35 ±	„	Distinctly separated, with black line between.
·192	35·5	...	„	Angle certainly not smaller than this value.

In September last the star was moderately elongated in angle 11° , but no trace of separation could be seen, though examined under good seeing with a power of 1000; now it is distinctly separated with a black line between the components, with a power of only 500, and cannot be regarded as a very difficult object for the great Telescope.

The distance at present can hardly fall short of $0''\cdot32$, while in September it certainly was not more than half this value.

This object was discovered by Burnham with the Chicago $18\frac{1}{2}$ -inch Clark refractor in 1879·0, and measured on one night. The components of the close pair (there is a third component in $152^\circ\cdot2$, $18''\cdot22$, 13th magnitude) have always been noted as nearly equal (generally as 7·8 and 8), differing at most by one or two tenths of a magnitude; and hence I suspect that the first angle given as $17^\circ\cdot5$ ought to be increased by 180° . If the stars are sensibly equal the observers almost involuntarily adopt the smaller of the two possible position-angles. Our recent observations give an additional ground for this correction by showing that the stars are not separated in angle $17^\circ\cdot5$, and hence it is improbable that the distance would have been given as $0''\cdot35$.

The observations of Schiaparelli in 1887, 1888, 1889, 1890, show that the motion is rapid, and indicate that the period is only a few years. In 1891 the star was single to Schiaparelli and also to Burnham, who examined it on several nights; which would imply that the companion was then in periastron.

In 1891·97 it was observed by Burnham, who concluded that 100° had been swept over by the radius vector since 1879·0. In 1894·65 Professor Barnard observed it, at my request, and found the angle to be $173^\circ\cdot5$. While observing double stars at Madison in September 1895, I took occasion to measure this object, and found that it was close, but nicely separated with the $15\frac{1}{2}$ -inch refractor.

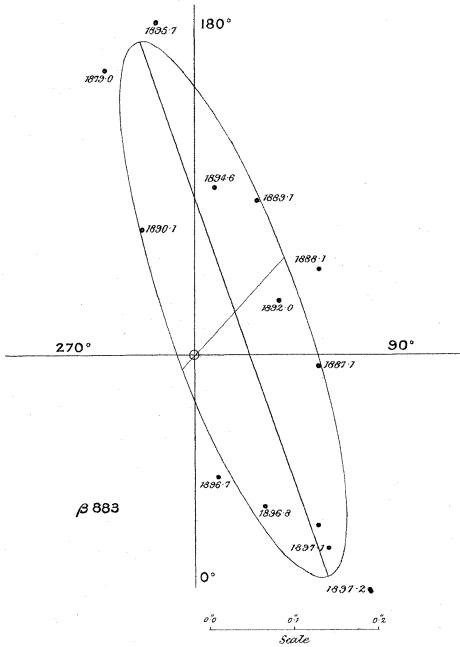
Mr. Moulton's measure was in substantial agreement with my own, and neither of us regarded it as a very difficult object for a good telescope. I have no record of any subsequent measures until the beginning of our work at Flagstaff. In September it certainly was slightly elongated, but not a trace of separation could be seen. In our subsequent observations we were equally unable to get evidence of separation until November 4, when with a power of 1000 and good seeing there appeared for the first time some evidence of "notching." As soon as observations were begun in Mexico I took occasion to examine this object. It then appeared for the first time actually separated, though still very close. In the subsequent observations the object became easier and easier, until now the star is well separated with a black line between the components, and the division can be seen with comparative ease even if the observer has little experience or the seeing is not the very best. We estimate the seeing on a scale of 10; that at Flagstaff was uniformly rated at 7; here in Mexico it has been rated at 4 and 5. The atmospheric conditions here were certainly not so good as those at Flagstaff.

Under these circumstances I do not hesitate in the belief that the companion has recently passed periastron, and that we have observed it widen out from month to month, until it is now within the reach of moderate sized telescopes. I have, therefore, investigated the general nature of the orbit, and herewith submit an approximate set of elements, which will be sufficiently exact for the use of observers.

The following considerations enable us to derive the essential element of the apparent orbit.

1. The motion since 1895·7, over an arc of 210° , indicates that the period will be very short, probably not far from five years; the observations of Schiaparelli point to a similar conclusion, and hence if we take the angle in 1879·0 to be $197^\circ\cdot5$ we may conclude that three revolutions have been performed between that date and 1896; whence we deduce a period of about 5·5 years. All the observations are consistent with such a period except that of Burnham in 1891·97, where the angle appears to be in error about a quadrant. On inquiring of him whether there could be an error in the reduction of the angle, he writes that he does not think there can be an error of a quadrant in the published measure.

We shall at present make no attempt to assign the cause of the discrepancy. The other observations indicate an error of



some kind, and we must reject either the one observation or all the others combined.

Even if all the other observations be discarded there will still be a case of rapid motion, as the angle is now 90° , or 270° different from that recorded in 1891.97.

2. The elements of the orbit are as follows :—

$$\begin{array}{ll} P = 5.5 \text{ years} & a = 0''.621 \\ T = 1896.40 & \Omega = 20^\circ.6 \\ e = 0.760 & i = 82^\circ.52 \\ & \lambda = 273^\circ.83 \end{array}$$

Apparent orbit :—

$$\begin{array}{ll} \text{Length of major axis} & = 0''.67 \\ \text{Length of minor axis} & = 0''.16 \\ \text{Angle of major axis} & = 19^\circ.5 \\ \text{Angle of periastron} & = 318^\circ.0 \\ \text{Distance of star from centre} & = 0''.07 \end{array}$$

The apparent orbit shows the general nature of the motion, and indicates very decidedly that the period cannot much surpass 5.5 years, and that the eccentricity and inclination are very high.

Comparison of Computed with Observed Places. β 883.

<i>t</i>	θ_0	θ_c	$\theta_0 - \theta_c$	ρ_0	ρ_c	$\rho_0 - \rho_c$	N.
1879.00	197.5	191.0	+ 6.5	0.35	0.37	− 0.02	1
1887.15	84.7	54.9	+ 29.8	0.15	0.21	− 0.06	3
1888.06	124.4	130.2	− 5.8	0.18	0.15	+ 0.03	2
1889.14	158.5	179.2	− 20.7	0.20	0.31	− 0.11	4
1890.14	203.4	195.5	+ 7.9	0.16	0.30	− 0.14	3
1891.14	single	22.4	...	...	0.24	...	1
1891.15	„	22.4	...	...	0.24	...	2
1891.97	33.1 ? 123.1	36.1	− 3.0 ?	0.12	0.30	− 0.18	3
1893.07	single	80.1	...	...	0.16	...	1
1894.65	173.5	178.8	− 5.3	0.20	0.31	− 0.11	1
1895.15	uncertain	190.9	...	...	0.37	...	1
1895.74	186.4	193.3	− 6.9	0.39	0.35	+ 0.04	2
1895.74	188.9	193.3	− 4.4	...	0.35	...	1
1896.692	11.0	23.3	− 12.3	0.15 ±	0.25	− 0.10	2
1896.805	25.1	25.3	− 0.2	0.20 ±	0.31	− 0.11	2
1897.073	34.4	29.6	+ 4.8	0.28	0.31	− 0.03	2
1897.162	35.5	31.0	+ 4.5	0.25	0.31	− 0.06	3
1897.162	36.0	31.0	+ 5.0	0.35	0.31	+ 0.04	1
1897.192	37.5	31.4	+ 6.1	0.35	0.31	+ 0.04	2

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3. It is now clear that Mr. Burnham's supposition, that the motion from 1879.00 to 1892 amounted to 100° , fell far short of the truth. At that time it must have amounted to about two and one half revolutions. For during the interval since 1892 the companion has swept over an arc of 270° ; even if it were admissible to suppose that it is now in the third quadrant instead of the first (indicated by our observations), we should still have a motion of 90° since 1892, which contradicts the hypothesis of slow motion. Supposing that only 90° have been described since 1892, the slow motion hypothesis is contradicted by the observations of Schiaparelli in 1887, 1888, 1889, and by our inability to see the pair separated in 1896 with the 24-inch, whereas the object was easily divided in 1895.7 with a $15\frac{1}{2}$ -inch telescope. Also, if the motion is slow the minimum change which can have taken place since 1892 (90°) requires that the orbit should be much extended in the first quadrant, and hence the star would have been wide and easy at the time of Schiaparelli's observations; he actually found it close and difficult and, except in the first case, in the second and third quadrants. It is, therefore, clear that the motion of this system is very rapid, and that no other hypothesis will explain the phenomena.

The results here submitted give only a first approximation to the orbit, and doubtless some improvement of the elements will soon be possible. This remarkable object ought to be followed from month to month during the whole time it is visible. By securing a closely connected series of observations we shall soon be able to render the orbit very exact.

The discovery of an object revolving in a period of 5.5 years is an achievement of some philosophic significance in the history of double star astronomy. In the time of Sir John Herschel the most rapid of known binaries was ζ *Herculis*, with a period of 35 years. Twenty years ago the remarkable object 42 *Comæ Berenices* had reduced the shortest period to about 25 years, and in 1887 δ *Equulei* brought it down to 11.5 years. κ *Pegasi* (β 989) has since been shown to revolve in a similar period.

In β 883 we have for the first time a visible binary with a period fairly approaching those of the spectroscopic binaries recently discovered, and we seem assured that at last a link has been found connecting the two classes of objects. It is probable that other stars will disclose even shorter periods, for there is no reason why there should not be close doubles with periods of a single year or less. It will be an interesting object of future research to fill in the intervening steps between visible binaries with periods of a few years and the spectroscopic binaries revolving in a few days or months.

The more critical inquiry into the motion of close doubles will commend itself to the attention of double star observers with great telescopes, and on the other hand it may be hoped that the study of the relative motion in line of sight of the com-

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with a Period of $5\frac{1}{2}$ Years.

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ponents of binaries like β 883 will be taken up by some of our great observatories equipped with powerful spectroscopic appliances.

*Lowell Observatory, City of Mexico :
1897 March 12.*

Since the above paper was forwarded to the Secretary I have received from Professor Barnard full details of his observations in 1894. These measures are very important, and since they are not all included in the above list, they are here condensed.

t	θ_0	ρ_0	Remarks.
1894.649	173.5	0.20	Seeing 4 (scale of 5); the stars are north and south; power, 1500.
1894.668	176.8	0.20	Seeing, 4-5; power, 1500.
1894.671	178.7	0.16	Seeing, 5; power, 1500. Stars very close.

The instrument used was of course the 36-inch refractor.

These measures leave absolutely no doubt of the rapid motion between 1892 and 1894, and are therefore in accordance with the results given in the foregoing paper.

*Lowell Observatory, City of Mexico :
1897 April 7.*

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